BIOLOGICAL EVALUATION REGARDING EPA APPROVAL OF THE CALIFORNIA CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

BASIN PLAN AMENDMENT FOR THE CONTROL OF SALT DISCHARGES INTO THE SAN JOAQUIN RIVER UPSTREAM OF VERNALIS

REGARDING SPECIES UNDER THE JURISDICTION OF THE NATIONAL MARINE FISHERIES SERVICE

PREPARED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION 9
WATER QUALITY ASSESSMENT SECTION (WTR 2-1)

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Introduction

This Biological Evaluation (BE) analyzes the U.S. Environmental Protection Agency's (EPA) action on the State Water Resources Control Board (State Board) approval of changes to the Central Valley Regional Water Quality Control Board (Regional Board) Basin Plan amendments to adopt new salinity standards –expressed as electrical conductivity (EC) measurements- for the Lower San Joaquin River (LSJR).

In 2000, the State Board directed the Regional Board to adopt a Salt and Boron Control Program in the LSJR. Phase 1 of the Control Program was adopted by the Regional Board in 2004. Phase 1 implemented Total Maximum Daily Load (TMDL) requirements on discharges to the LSJR to maintain compliance with water quality objectives in the Bay-Delta Plan at Vernalis.

The Regional Board adopted these amendments on June 9, 2017. The State Board adopted the amendments on January 9, 2018 and they were approved by the Office of Administrative Law on April 19th, 2018. The salinity objectives were submitted to EPA for review under CWA 303(c) on April 20, 2018. The objectives, once approved by EPA, would go into effect on January 1, 2020.

Although salinity has been recognized as a water quality problem in the Lower San Joaquin River, there currently are no established salinity objectives for the river upstream of Vernalis. This Basin Plan amendment addresses Phase 2 of the Control Program by setting salinity objectives for Reach 83 of the Lower San Joaquin River. This amendment does not change the current Phase 1 TMDL requirements to meet the Bay-Delta Plan water quality objectives for Vernalis.

This biological evaluation considers potential impacts to listed species and critical habitat under the jurisdiction of the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act (ESA) and 50 CFR Section 402.13(a).

Description of Action

This action focusses on effects of EC on threatened and listed species under the jurisdiction of the NMFS. The basin plan amendment states that, "The objectives for electrical conductivity and total dissolved solids in Table III-3 apply to the water bodies specified. To the extent of any conflict with the general Chemical Constituents water quality objectives, the more stringent shall apply, with the exception of the electrical conductivity water quality objectives for Reach 83 of the San Joaquin River, which the Board has determined to be protective of all beneficial uses within Reach 83." The Mouth of the Merced River to Vernalis (Reach 83) has the following designated uses: Municipal and Domestic Supply, Agriculture, Industry (Process), Recreation, Fresh-Water Habitat (Warm), Migration, Spawning (Warm), and Wildlife Habitat.

The criteria under Table III-3 state that Electrical Conductivity (at 25°C) for San Joaquin River between the Mouth of Merced River and the Airport Way Bridge near Vernalis (83) shall not exceed 1550 micromhos/cm (as a 30-day running average), except during Extended Dry Periods, when concentrations shall not exceed 2470 micromhos/cm (as a 30-day running average) and

2200 micromhos/cm (as an annual average using at a minimum the previous four quarterly samples).

The Extended Dry Period is determined using Hydrologic Classification and the 60-20-20 rule as defined in the State Water Board Revised Water Right Decision 1641, March 2000. San Joaquin Valley Water Year Hydrologic Classification is determined by Equation 1 and Table 1. An Extended Dry Period shall begin when the sum of the current year's 60-20-20 (numeric) indicator value and the previous two years 60-20-20 (numeric) indicator values total six (6) or less. An Extended Dry Period shall be deemed to exist for one water year (12 months) following a period with an indicator value total of six (6) or less.

Equation 1. San Joaquin Valley Water Year Hydrologic Classification

$$Index = 0.6X + 0.2Y + 0.2Z$$

Where X = Current year's April – July San Joaquin Valley unimpaired runoff
Y = Current October – March San Joaquin Valley unimpaired runoff
Z = Previous year's index

Table 1. Water year classification index categorization by numeric indicator.

Numeric Indicator	Classification	Millions of Acre-Feet (MAF)
5	Wet	Equal to or greater than 3.8
4	Above Normal	Greater than 3.1 and less than 3.8
3	Below Normal	Equal to or less than 3.1 and greater than 2.5
2	Dry	Equal to or less than 2.5 and greater than 2.1
1	Critical	Equal to or less than 2.1

Description of the Area Affected

The reach of the LSJR from the Merced River to Tuolumne River is 34.7 miles in length (Figure 1). The major tributaries draining the eastside of the project area in this reach are the Merced and the Tuolumne Rivers, while Orestimba, Salado, and Del Puerto Creeks drain the west side. The LSJR from the Tuolumne River to the Stanislaus River is 8.4 miles in length and is drained on the west side by Ingram and Hospital creeks, and includes the Maze Road monitoring site. The stretch from the Stanislaus River to the Airport Way Bridge, near Vernalis is 2.7 miles in length. The total area affected is therefore about 46 miles. Below Vernalis, a more stringent water quality criterion for salinity of 0.7 mmhos/cm applies (although that is proposed in a separate rulemaking process to be changed to 1.0 dS/m). Therefore, the scope of area affected in this analysis is limited to Reach 83.

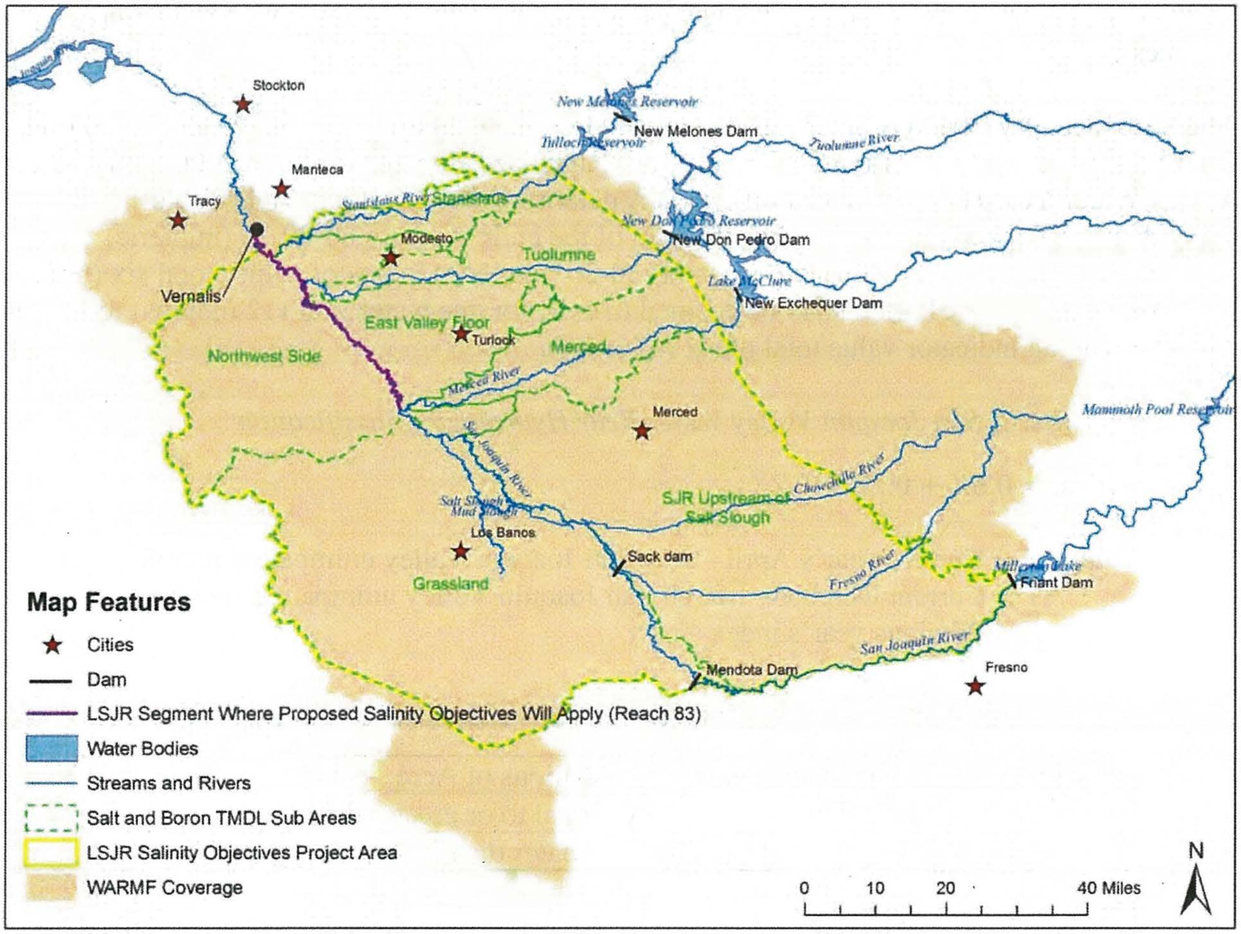

Figure 1. San Joaquin River between the Mouth of Merced River and the Airport Way Bridge near Vernalis (83)

Listed Species

The species for consideration in this biological evaluation were identified from NOAA Fisheries West Coast Region California Species List Tools and an official ESA species list was obtained electronically from NMFS online tools[1] and correspondence[2] (see Table 2 and Figure 2). This analysis considers two ESA anadromous fishes and their critical habitat: Threatened California Central Valley Steelhead (*Oncorhynchus mykiss*), Threatened Southern Distinct Population Segment Green Sturgeon (*Acipenser medirostris*), and Threatened Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*); as well as essential fish habitat for Chinook Salmon.

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[1] NOAA Fisheries West Coast Region California Species List Tools http://www.westcoast.fisheries.noaa.gov/maps_data/california_species_list_tools.html. Accessed August 7, 2018.

[2] Notice of Insufficient Information to Initiate Endangered Species Act Section 7(a)(2) Consultation for the Control of Salts Discharges into the San Joaquin River Upstream of Vernalis. Letter from Erin Strange to Janet Hashimoto received November 14, 2018. NMFS File Number WCR-2018-11053

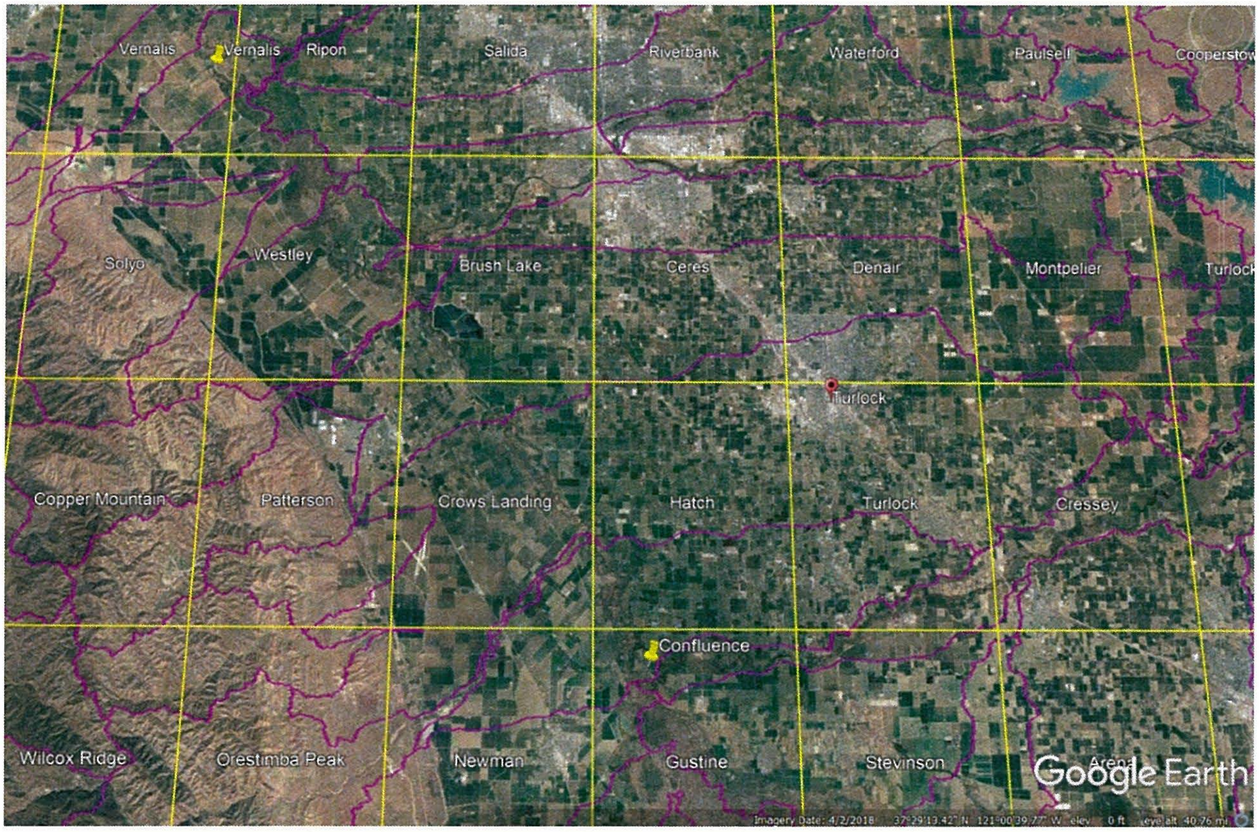

Figure 2. Action area with revised salinity water quality standards from Merced and San Joaquin River Confluence to Vernalis displayed with National Marine Fisheries Service NMFS West Coast Region California Species List Quadrangles.

Table 2. ESA Anadromous Fish, Critical Habitat, and Essential Fish Habitat from the action area with revised salinity water quality standards.

		ESA ANADROMOUS FISH			ESA ANADROMOUS FISH CRITICAL HABITAT		ESSENTIAL FISH HABITAT
Quad Name	**Quad Number**	**Steelhead California Central Valley (Threatened)**	**Southern Distinct Population Segment Green Sturgeon (Threatened)**	**Central Valley Spring-Run Chinook Salmon (Threatened)**	**Steelhead California Central Valley**	**Southern Distinct Population Segment Green Sturgeon**	**SALMON Chinook**
Brush Lake	37121-E1	X		X	X		X
Crows Landing	37121-D1	X		X	X		X
Gustine	37120-C8	X		X	X		X
Hatch	37120-D8	X		X	X		X
Ripon	37121-F2	X	X	X	X	X	X
Vernalis	37121-F3	X	X	X	X	X	X
Westley	37121-E2	X		X	X		X

X = Present on the Quadrangle and/or Presence Indicated by NMFS in correspondence.

Life Histories

Threatened California Central Valley Steelhead (*Oncorhynchus mykiss*)

Description

The Central Valley Steelhead (*Oncorhynchus mykiss*) was once widespread throughout the Central Valley (Lindley et al. 2006). They are the anadromous form of rainbow trout, meaning they migrate from the ocean up river to spawn. Resident rainbow trout and steelhead were historically considered separate species (or at least subspecies; USDOI 2008), but other research has shown little to no differences between the two in terms of morphology and genetics (Behnke 1972, Allendorf 1975, Allendorf and Utter 1979, Busby et al. 1993, Nielsen 1994, all as cited by McEwan and Jackson 1996). In terms of identification, one very distinguishing feature of the steelhead are the numerous black spots on the caudal fin, adipose fin, dorsal fin and back (Moyle 2002). Steelhead often display a pinkish to red lateral band and pinkish cheeks along with a back that is typically iridescent blue to brown, with sides and belly typically silver, white, or yellowish (Moyle 2002). Juvenile coloration is very similar to adult with slight differences including parr marks and differences in fin and tail coloration (Moyle 2002).

History

The steelhead is the anadromous form of the rainbow trout (McEwan and Jackson 1996). Steelhead have an interesting life cycle in that populations are able to revert back and forth from being anadromous to resident, or vice versa. Zimmerman et al. (2008) found that resident rainbow trout are able to produce anadromous smolts, and that anadromous steelhead are able to produce resident rainbow trout within the Central Valley. Peak migration in the Central Valley occurs in fall and early winter, but is known to occur throughout the year to some degree. Given this fact, most Central Valley steelhead are termed 'winter steelhead'. Summer steelhead (i.e., those migrating in the summer months) do also occur, but to a much lesser extent (USDOI 2008).

Spawning occurs mainly in gravel substrates (NMFS 2014). Once hatched, the fry and alevins remain in the gravel for another four to six weeks (Shapovalov 1937 cited in Shapovalov and Taft 1954), after which the fry move to shallow protected areas within the stream margin (Barnhart 1986) to feed predominantly on immature aquatic insects (Merz 2002). Following one to three years in freshwater, juvenile Central Valley Steelhead may migrate to the ocean (McEwan and Jackson 1996). Smoltification of juveniles occurs during downstream migration, and enables them to tolerate the ocean environment and its increased salinity (USDOI 2008). Upon reaching the ocean, steelhead are known to remain there for one to four growing seasons prior to returning to spawn in their streams of origin (Burgner et al. 1992).

Distribution

Distribution and abundance data for the Central Valley steelhead is limited in comparison to other fish species due in part to its unique life history characteristics and historic alteration of spawning rivers (Yoshiyama et al. 1996). Prior to dam construction as well as other watershed perturbations occurring in the 19th and 20th centuries, steelhead ranged throughout many of the tributaries and headwaters of the Sacramento and San Joaquin rivers (McEwan and Jackson 1996). Historically it has been estimated that 81 independent Central Valley steelhead populations existed, primarily in the eastern tributaries of the Sacramento and San Joaquin rivers (Lindley et al. 2006). Lindley et al. (2006) have estimated that dams have blocked 80 percent of the historically available habitat including all historical spawning habitat for about 38 percent of historical populations.

Steelhead distribution within the Central Valley has been greatly reduced over the years, although more recent monitoring has detected small populations in the Stanislaus, Mokelumne, and Calaveras rivers as well as other streams in the area previously thought to be devoid of the species (DFG unpublished data, Demko and Cramer 1997, 1998, Demko and others 1999, all cited in McEwan 2001). USDOI (2008) has indicated that they believe that spawning populations might exist in other streams in the region, but a lack of monitoring and research data hinders an accurate understanding. For this same reason, it is unclear what historic and current role the Sacramento-San Joaquin Delta has played as nursery habitat (USDOI 2008).

Threats to Species

The threats to the Central Valley steelhead have resulted in the species being listed under the ESA. These threats result from the widespread degradation and blockage of freshwater habitats in the Central Valley from water management activities. Factors related to the effects of water management activities include loss of spawning and rearing habitat, effects on predation and competition, effects on food abundance, disease and parasites, pollution, and the effects of hatchery-reared fish on natural populations of steelhead (USDOI 2008).

It has been estimated that 80% of the historically available habitat of the Central Valley steelhead has been lost due to the construction of dams and the resultant loss of habitat (Lindley et al. 2006). It is thought that anadromous populations of steelhead might have been extirpated from their entire historical range in the San Joaquin Valley and most of the larger basins in the Sacramento River (NMFS 2014). Remaining habitat in the Central Valley has been drastically altered and degraded, providing inadequate flows, higher water temperature, and general inaccessibility to rearing habitat (Reynolds et al. 1993). Land use practices including forestry, agriculture, and urbanization are also recognized as contributors to the decline of the Central Valley steelhead (McEwan 2001).

Recovery Plans

Various conservation measures have been taken to improve habitat quality for the Central Valley steelhead, including the Clear Creek Restoration Program, the Battle Creek Salmon and Steelhead Restoration Project, several actions taken by the Anadromous Fish Restoration Program and the Ecosystem Restoration Program, the Lower Yuba River Habitat Restoration Project, and actions under the San Joaquin River Restoration Program. Other measures taken to protect steelhead in the region include adipose fin-clipping of hatchery-reared fish and improved inland fishing regulations (NMFS 2014).

Critical Habitat

The NMFS proposed critical habitat for Central Valley steelhead on December 10, 2004 (69 FR 71880) and published a final rule designating critical habitat for this species on September 2, 2005 (70 FR 52488). According to NMFS (2014), the primary constituent elements considered by NMFS to be essential for the conservation of the Central Valley steelhead are those sites and habitat components that support one or more life stages and includes:

> Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks; freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival; estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation (see 50 CFR 226.211(c)).

Threatened Southern Distinct Population Segment Green Sturgeon (*Acipenser medirostris*)

Description

The North American Green Sturgeon (*Acipenser medirostris*) is an anadromous fish (Riede 2004 cited in Froese and Pauly 2016) that inhabits the nearshore Eastern Pacific Ocean from Alaska to Mexico. (Birstein 1993 cited in Froese Pauly 2016). They are similar in appearance to white sturgeon, with some slight differences including coloration, green sturgeon are a slight olive green, rather than a pinkish yellow. Other distinguishing traits such as position of mouth barbels are too subtle for the average fisherman to distinguish and green sturgeon are often misidentified as white sturgeon (Froese and Pauly 2016; Beamesderfer et al. 2004). Green sturgeon can reach more than 8 feet in length (Love et al. 2005) and weigh up to 350 pounds (Eschmeyer et al. 1983 cited in Froese and Pauly 2016).

Two distinct populations of North American green sturgeon exist. The northern distinct population segment (nDPS) spawns in the Klamath River, California and Rogue River, Oregon and is listed as a Species of Concern in 69 FR 19975. The southern distinct population segment (sDPS) spawns exclusively in the upper-main stem Sacramento River and was listed as a threatened species by NMFS in 2006 (NMFS 2010).

Green sturgeon have a long lifespan, only reaching sexual maturity at about 15 years of age (Van Eenennaam et al. 2006). They spawn multiple times in a lifespan, every 3-5 years (California Fish Tracking Consortium database cited in NMFS 2010). Spawning migration from the Pacific Ocean to the upper Sacramento River begins in late winter after river flows increase from snow melt (NMFS 2015; Erickson and Webb 2006). Spawning occurs from April through July in deep pools containing small to medium sized gravel, cobble or boulder substrate (Poytress et al. 2009). Both temperature and water flow are important cues to initiate spawning migration, as well as, choosing a location to lay eggs (NMFS 2015; Erickson and Webb 2006).

Fertilized eggs incubate for seven to nine days and disperse from the hatching area 18 to 35 days post hatch. (Van Eenennaam et al. 2001). Laboratory studies found that the change from larvae to juveniles occurred at approximately 45 days post-hatch (Deng et al. cited in NMFS 2015). Larvae and juveniles migrate toward the Sacramento-San Joaquin Delta, where they rear for one to four years before migrating out to the Pacific Ocean (NMFS 2010; Erickson and Hightower 2007).

History

In response to a 2001 petition to list the North American Green Sturgeon as an endangered species a status review was conducted by a Biological Review Team (BRT). The BRT concluded that the green sturgeon should be listed as candidate species and its status was to be further reviewed in a five year period (NMFS, 2015; Adams et al. 2002).

The status review was updated in 2005 by NMFS Southwest and Northwest Fisheries Science Centers in response to a 2004 court ruling that further consideration of their endangered or threatened status was necessary (BRT 2005 cited in NMFS 2015). The BRT concluded that the nDPS was not in danger of extinction, however the sDPS was likely to become endangered in the foreseeable future (NMFS 2015).

NMFS published a notification listing the sDPS of North American Green Sturgeon as threatened and the nDPS of North American Green Sturgeon as a species of concern in 2006 (71 FR 17757) (NMFS 2015).

Distribution

North American Green Sturgeon spend the majority of their lives, with the exception of rearing and spawning, in coastal waters from the Bering Sea, Alaska to Baja California, Mexico (Huff et al. 2012). It is only during the migration and spawning season, late winter through early fall, that adult green sturgeon are reported throughout the Sacramento tributaries. Spawning in the San Joaquin has not been documented, but might have occurred prior to the construction of largescale hydropower and irrigation development (NMFS 2010; Beamesderfer et al. 2004; Adams et al. 2002). Juveniles primarily occupy the Sacramento-San Joaquin Delta, where they rear for as long as four years, until migrating to the Pacific Ocean (NMFS 2010).

Threats to Species

The primary threats to the sDPS of green sturgeon are alteration and destruction of spawning habitat, limiting population size and resilience (NMFS 2010). The construction of hydropower dams and irrigation for agriculture limit the accessibility of viable spawning areas of the Sacramento River. Historical harvesting of adult sturgeon also likely reduced the population abundance (NMFS 2010). Hydropower dams, not only pose a physical barrier to potential spawning areas, but alter the flow and temperature of accessible areas in the Sacramento River, further depleting spawning habitat (NMFS 2010). Flow and temperature provide spawning cues to adult sturgeon and these alterations may also inhibit upstream migration to spawning areas (NMFS 2010; Heublein et al. 2009; Poytress et al. 2013).

Hydraulic suction dredging in the San Francisco Bay Estuary/Delta to maintain adequate depth for ship navigation poses a threat to juvenile green sturgeon rearing in the same area. Dredging presents potential threats including food limitation, exposure to contaminants, and physical burying of individuals, all of which inhibit juveniles from reaching reproductive age (NMFS 2010).

Harvesting of eggs by poachers for sturgeon caviar is a threat on a smaller scale, but increasing flow may alleviate this stress by making spawning areas less accessible to humans (Beamesderfer et al. 2004).

Recovery Plans

Several recovery plans have been implemented to protect North American Green Sturgeon. Critical habitat designation has been established to ensure any activities that would adversely affect the species will not be carried out in these areas. Recreational and commercial retention of Green Sturgeon is prohibited along the west coast of North America, as well as, a year round ban on sturgeon fishing in the main stem Sacramento River to protect spawning adults. Construction of fish passages in the Red Bluff Diversion Dam and temperature control devices at the Shasta dam have alleviated isolation from viable spawning areas. Numerous other activities including floodplain river restoration, riparian habitat protection, relocation of green sturgeon, and research regarding contamination and genetic stability of green sturgeon have also been utilized to protect the species population (NMFS 2010)

Critical Habitat

Designated in 2009, critical habitat for sDPS green sturgeon includes marine, coastal bay, estuarine, and freshwater areas. Marine areas range from Monterey Bay, California to the U.S.-Canada border. Coastal bays and estuaries designated as critical habitat are found in California (San Francisco Estuary and Humboldt Bay), Oregon (Coos, Winchester, Yaquina, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor). The Columbia River estuary, located between Oregon and Washington is also of concern. Freshwater critical habitats encompass all of these states and include the main stem Sacramento River downstream of Keswick Dam (including the Yolo and Sutter bypasses), the Feather River below Fish Barrier Dam, the Yuba River below Daguerre Point Dam, and the Sacramento-San Joaquin Delta (NMFS 2010).

Food resources, substrate type and size, water flow, water depth, water quality, sediment quality, and migratory corridor were the Primary Constituent Elements (PCEs) used to determine critical habitat for the sDPS green sturgeon (NMFS 2010).

Threatened Central Valley spring-run Chinook Salmon (*Oncorhynchus tshawytscha*)

The Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha)* spawn in the late summer and early fall, and require stream reaches with cold water sources to foster growth and propagation. This life history trait has relegated their spawning grounds primarily to the mainstem of the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (CDFW, 1998; NOAA 2014).

Adult Central Valley spring-run Chinook salmon migrate upstream through the Delta and into the lower Sacramento River from late January to early February (CDFW 1998), with the majority reaching the Sacramento River in May and June (Fisher et al. 1994; USFWS 1995). Migration occurs while the salmon are still sexually immature, and adults must hold in deep, cool pools for a period of several months to mature (Marcotte 1984 cited in Moyle et al. 1995; USFWS 1995). Adults have matured enough to spawn between mid-August and early October, with peak spawning in September (CDFW 1998; Fisher 1994; USFWS 1995). Eggs hatch in 40 to 60 days, and the larvae, or alevins, remain in the gravel for four to six weeks, surviving off their yolk, before becoming feeding fry (Moyle 2002). Fry search out streamside habitats that foster the larval and adult invertebrates on which they feed, and that provide cover and reduced water velocities to minimize energy expenditure (Lister and Genoe 1970). As juveniles grow, they will seek deeper water with higher current velocities (Chapman and Bjornn 1969; Lister and Walker 1966). Juveniles may stay in freshwater for a period of weeks, migrating to the ocean in the winter or spring as young-of-the-year, or they may remain in freshwater for periods of over a year (Healey 1991, CALFED 2000b cited in NOAA 2014). Upon reaching the ocean, Chinook will grow rapidly as they feed upon small and larval fish, insects, amphipods, and cumaceans (Healey 1991; MacFarlane and Norton 2002). Adults reside in the ocean for 1–6 years before returning to freshwater at the end of their lives to spawn (Healey 1991).

History

Spring-run Chinook salmon were historically ubiquitous in river headwaters of the Central Valley (NOAA 2014). They were present in the region that is currently used by winter-run Chinook salmon as well as the northern and southern Sierra Nevada and in north western California (Lindley et al. 2007). Under historic conditions, spring-run Chinook salmon may have been the most abundant salmonid in the Central Valley (Shebley 1922 cited in Fisher 1994). Between the 1880s and 1940s, runs of spring-run Chinook in the Central Valley could have reached sizes as large as 600,000 fish (CDFW 1998). Close to 567,000 spring-run Chinook salmon were caught in the Sacramento-San Joaquin commercial fishery in 1883 (CFC 1884 cited in Yoshiyama et al. 1998). However, numbers have declined significantly since the 19th century. The San Joaquin populations were essentially extirpated by the late 1940s, with only small remnants of the run persisting in tributaries through the 1950s (Hallock and Van Woert 1959). In the last few decades, spring-run sizes have fluctuated between 3,000 to 30,000 fish (NOAA 2014).

Reductions of populations were noted as early as the 1880s and attributed to harvesting and degradation of the environment including water development and dam construction (NOAA 2014). Most notably, severe declines occurred as the construction of large dams, such as the Friant, Oroville, and Shasta dams, eliminated access to almost all historical habitat and spawning grounds of the spring-run Chinook salmon (Fisher 1994; NOAA 2014).

In the mid-1960s, after dam construction led to further habitat loss for Chinook salmon, the Feather River Fish Hatchery (FRFH) was constructed. The FRFH is the only hatchery in the Central Valley rearing spring-run Chinook salmon, and has a current production target of two million smolts (NOAA 2014). However, past and present hatchery practices have led to considerable hybridization between spring- and fall-run Chinook salmon, which may lead to homogeneity among the Central Valley Chinook salmon runs (DWR 2004a cited in NOAA 2014). This especially threatens the genetic integrity of the only remaining naturally occurring spring-run populations in Deer, Mill, and Butte creeks (DWR 2004a cited in NOAA 2014).

This Evolutionarily Significant Unit (ESU) was listed as threatened on September 16, 1999 (64 FR 50394), and reaffirmed as threatened on June 28, 2005 (70 FR 37160) following a five-year species status review (NOAA 2014).

Distribution

Deer, Mill, and Butte creeks are the only known creeks that still contain persistent populations of Central Valley spring-run Chinook that are self-sustaining and have not hybridized with salmon from other runs or hatcheries (CDFW 1998). Some of the spring-run persists in the Feather, Sacramento, and Yuba Rivers, but many of these fish have interbred and hybridized with the wild fall-run Chinook salmon (CDFW 1998). These populations are small and isolated, and their range is restricted. The current reduced distribution leaves the Central Valley spring-run Chinook salmon vulnerable to genetic risks and catastrophes including drought, wildfire, and having headwaters that lie within the debris and pyroclastic flow radii of Mt. Lassen (Hoblitt et al. 1987; Lindley et al. 2007).

Threats to Species

Major threats that Central Valley spring-run Chinook salmon face include loss of most historical spawning habitat, degradation of remaining habitat, and genetic introgression among Chinook populations (NOAA 2014). The historical spawning and holding habitats of spring-run Chinook salmon in cool freshwater are mostly upstream of impassable dams (Moyle 2002; Lindley et al. 2007). Human modifications such as dams and water diversions have reduced and degraded habitat of the spring-run Chinook salmon (NOAA 2014). These modifications may make habitats inaccessible, reduce flow conditions, increase temperatures, and introduce non-native predators (NOAA 2014). Dams alter reproductive isolation, threatening genetic integrity of the spring-run Chinook salmon. There has been introgression with fall-run Chinook salmon in the wild, introgression in hatcheries between spring- and fall- broodstock, and the release of hatchery-produced juveniles in the San Francisco estuary contributes to straying of returning adults throughout the Central Valley (NOAA 2014).

Recovery Plans

A number of recovery actions in the Sacramento tributaries have focused on improving access to spawning habitat, increasing flows, restoring habitats, and reducing juvenile loss at water diversions (NOAA 2014). Specific projects include providing better screens for water diversions, discouraging illegal fish harvest, dam removal, and installation of barriers that can guide fish away from undesirable habitats. Projects with the most impact for Central Valley spring-run Chinook salmon have improved passage flows on Mill and Deer creeks, and improved fish screens and fish ladders on Butte Creek (NOAA 2014).

Critical Habitat

The critical habitat for Central Valley spring-run Chinook salmon is designated as sites that support one or more life stages (50 CFR 226.211(c)), including quality spawning sites, rearing sites, migration corridors, and estuarine areas (NOAA 2014). The NMFS published a final rule designating critical habitat for Central Valley spring-run Chinook salmon on September 2, 2005 (70 FR 52488). The specific critical habitat was designated as river reaches of the Sacramento River and its California tributaries, as well as river reaches and estuarine areas of the Delta, "all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge" (NOAA 2014).

Effects Analysis for *O. mykiss, A. medirostris & O. tshawytscha*

As with other fishes, salinity affects the habitat and life history of *O. mykiss*, A. *medirostris* and *O. tshawytscha*. Although salinity tolerances may vary between species (and specifically between the distantly related *Oncorhynchus* and *Acipenser* genera) based on their overlapping geographic distribution in the project area, shared anadromous life history, and conserved physiological traits, salinity is likely to affect them through some similar modes of action, as described below: Osmoregulatory Acclimation, Straying, and Other Indirect Impacts.

Osmoregulatory Acclimation

The life histories of anadromous fishes require osmoregulatory acclimation as they migrate across salinity gradients. As juvenile salmon migrate downstream to the ocean (where total solutes are roughly three times as concentrated as their body fluid), and as adults return upstream to spawn (where the freshwater is nearly devoid of ions), they face the physiological challenge of maintaining body fluid concentration within homeostatic limits. Osmoregulatory adaptions can be triggered by early-life history developmental changes, by photoperiod of later life stages (the parr-smolt transformation in salmonids), and ultimately by direct contact with salinity (McCormick, 1994). For juveniles, an acclimation period in brackish waters of days to weeks may be required to allow for the activation of behavioral and physiological adaptations (altered drinking, kidney function, and active salt transport across gill epithelial cells). (Toolson 2018). A "smolt window" exists for adaption to seawater after which the smoltification process may be abandoned (a process known as parr-reversion). (Stefansson et al 2008).

Within the *Oncorhynchus* genus, seawater challenge tests have demonstrated the ability of juvenile *O. gorbuscha* and *O. keta* to rapidly adapt (<24 hours) to abrupt salinity changes (reflective of their life histories), whereas *O. kisutch, O. tshawytscha and O. nerka*, fry quickly die when exposed to 100% saltwater.[3] (Grant et al 2010; Weisbart, 1968; Clarke & Shelbourn, 1985). This acclimation entails energetic tradeoffs, as studies of *O. mykiss* and *O. tshawytscha* have shown that metabolic rates increased with salinity and were inversely correlated with growth rates (Morgan & Iwama, 1991). Based on similar seawater acclimation tests for *A. medirostris* (Allen et al, 2011), the authors concluded that:

> Juvenile green sturgeon develop structures and physiological changes appropriate for seawater entry while growing in fresh water, indicating that hypo-osmoregulatory changes may proceed by multiple routes in sturgeons...These results indicate that juvenile green sturgeon are capable of SW entry at a very young age and small size compared to other sturgeon species, supporting the findings of previous laboratory studies (Allen and Cech 2007; Allen et al. 2009a), field studies (Nakamoto et al. 1995), and trace element studies (Allen et al. 2009b)... Perhaps hypo-osmotic regulatory mechanisms can be stimulated by a number of internal (ontogenetic) and external (photoperiod) cues. Thus, if fish are

[3] Although *O. tshawytscha* fry appear unable to survive immediate transfer to ocean water salinity, they are able to survive 20 ppm or less per Groot & Margolis, 1991. Note that this reference lists units as ppm (parts per million), but in other sections describes the salinity of estuarine area as 2-25 ppt (parts per thousand). It appears that the reference to *O. tshawytscha* is intended to refer to ppt.

> flushed by strong currents downstream into saline areas, they may be able to survive if they can upregulate hyperosmotic regulatory mechanisms while remaining in brackish water. A number of studies have indicated that hyperosmotic regulation can be improved by acclimation to low to moderate salinities. At the same time, photoperiod probably cues preparatory changes that stimulate behavioral movements downstream and the upregulation of hypo-osmotic physiological regulatory systems.

Translating these laboratory findings into ecological meaningful salinity preferences in estuarine waters like the San Francisco Bay-Delta is complicated by the physical surroundings (stratified waters, channels, shoreline, fast and reserving tidal currents), variability in flows (and covariates such as temperature, dissolved oxygen, and salinity), and other stressors (predation pressure, prey scarcity, pollution). The ability of *Oncorhynchus* and *Acipenser* species to migrate through these waters indicates a degree of tolerance and plasticity, but this is contingent on life-stage and environmental conditions. For example, telemetry tracking studies of sub-adult and adult *A. medirostris* through San Francisco Bay have stated that: "One of the most notable findings was how rapidly the fish could move through a wide salinity range. In the span of 3 days, GS3 moved in excess of 45 km [San Pablo Bay to Sacramento River freshwater sloughs], and experienced a change in environmental salinity of at least 16.2 ppt, while moving from highly brackish water into almost fresh water." (Kelly, Klimley & Crocker, 2007). For juveniles, laboratory experiments demonstrated that freshwater-acclimated *A. medirostris* with no previous exposure to salt water displayed a clear preference for more saline waters, indicating that endogenous (innate developmental) mechanisms play a role in saltwater preparation – although the authors still advise that salinity management of the San Francisco Bay estuary and watershed should be further researched in order to further quantify this and balance Southern DPS *A. medirostris* recruitment with other water-related needs (Poletto et al, 2013). As Quinn summarizes for salmonids, our understanding of salinity tolerances, "…is hampered by the complex factors motivating fish movements, the complex physical oceanography of these waters, and the complex populations structure (hence route and schedule of migration and spawning)."

As the fishes migrate further up the LSJR into the Reach 83 action area, altered salinity may impose physiological stress, the impacts of which could be exacerbated or mitigated by other physicochemical parameters (flow, temperature, dissolved oxygen) and superimposed on variables such as health, predation, and habitat alteration. However, because it is difficult to replicate behavior adaption and ecological interactions in laboratory environments, a review of the literature did not present thresholds for the species of concern that could be compared against either ambient conditions, or the Regional Board's proposed salinity criteria. In summary, there is no available information indicating that these changes in salinity management would impair the ability of either the juveniles or adults of the species under consideration as they migrate through the affected area and adapt osmotically.

<u>Straying</u>

For diadromous fish, a combination of genetic and environmental factors mediate migratory behavior. For Pacific salmonids there is some evidence for navigational strategies based on flow, compass orientation, genetics, salinity gradients, celestial orientation (direction of polarized light), and olfaction (Quinn, 2011). Some research has highlighted the importance of salinity for salmon navigation stating that, "...juvenile Pacific salmon are able to use estuarial salinity gradients as one of the directive cues in their seaward migration" (McInerney, 1964). However, it's not clear how important of a factor salinity is, relative to other cues, as a 2006 review by Williams summarized:

> Some speculation about navigation by juvenile Central Valley Chinook and steelhead follows, based largely on the material in the reviews by Smith (1985) and Høgåsen (1998). Probably the dominant cues available to migrating juveniles are the flow of water and the position of the sun... The salinity gradient seems an obvious cue for orientation, but Smith (1985:77) notes that "... there is little evidence that salinity is a guiding mechanism," although the preference and tolerance of juveniles to salinity is appropriate for their migratory behavior. If salinity is really not a factor, then navigation through the bays is probably guided mainly by celestial and magnetic cues... Estuaries may be a transition zone in which fish switch from primarily visual and magnetic guidance to olfactory cues for navigation (Dittman and Quinn 1996), and acclimate to reduced salinity (Greene 1926)... [The cited study] illustrates the variability of the migratory behavior of adult Chinook. As a practical consequence, this variability makes it difficult to determine whether some factor or situation is delaying migration into the rivers.

Assuming that salmon require a monotonic salinity gradient to find their natal stream, the anthropogenically driven variability in salinity along the San Joaquin river could result in straying. Conversely, the suite of navigational adaptations, with an emphasis on olfaction, indicates that navigation via salinity gradients is potentially less important. Since salinity is covariate with other factors such as flow, it's difficult to parse out its relative importance in migration. In summary, there is no available information indicating that these changes in salinity management would measurably increase straying rates since salinity is likely a secondary cue, part of a suite of other navigational adaptions, for the returning *Oncorhynchus* and *Acipenser* adults.

<u>Other Indirect Impacts</u>

Changes in salinity could hypothetically impact the river ecosystem to shift food webs, but this point is speculative. Susceptibility to other pollutants can also interact with salinity, but studies indicate, for example, a reduced ammonia toxicity to *O. tshawytscha* parr in more saline waters (Harader et al 1983). In summary, there is no available information indicating that these changes in salinity management would impact toxicity of chemicals or predator/prey dynamics, for the species under consideration.

Conclusion

The EPA believes that the Threatened California Central Valley Steelhead (*Oncorhynchus mykiss*), Threatened Southern Distinct Population Segment Green Sturgeon (*Acipenser medirostris*), and Threatened Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*); as well as essential fish habitat for Chinook Salmon will not reasonably be expected to appreciably reduce the likelihood of both the survival and recovery of the aforementioned species by impairing the reproduction, numbers, or distribution of those species, and would not adversely modify or jeopardize the continued existence of their entire or listed populations.

The scale of the salinity objectives under consideration in the Lower San Joaquin habitat does not appear to be ecologically relevant to the species of concern and should never reach the scale where take occurs; or be discountable, where the effects are extremely unlikely to occur. Based on a review of the scientific literature and best judgment, it would be difficult to meaningfully measure, detect, or evaluate significant effects to the aforementioned populations of *O. mykiss*, *A. medirostris*, or *O. tshawytscha*. In conclusion, the EPA determines that the Regional Board's WQS may affect, but are not likely to adversely affect, any federally-listed fish species under NMFS responsibility.

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